

Abstracts of Bell System Technical Papers Not Published in This Journal

*Possible and Probable Future Developments in Communication.** O. E. BUCKLEY¹. *Franklin Inst. Jl.*, v. 251, pp. 58-64, Jan., 1951.

Electrochemical Industry. R. M. BURNS¹. Bibliography. *Ind. & Engg. Chem.*, v. 43, pp. 301-304, Feb., 1951.

*Cracking of Stressed Polyethylene; Effect of Chemical Environment.** J. B. DE COSTE¹, F. S. MALM¹, and V. T. WALLDER¹. *Ind. & Engg. Chem.*, v. 43, pp. 117-121, Jan., 1951.

ABSTRACT—In a number of applications for polyethylene, particularly cable sheaths and cosmetic containers, it has been found that under certain conditions failure of the polyethylene results in a cracking of the plastic. Considerable information is available to show that in an unstressed condition polyethylene is highly resistant to a wide variety of chemical environments such as alcohols, soaps, and fatty oils. However, when polyethylene is exposed to these environments under polyaxial stress it fails by cracking.

The work described in this paper was undertaken to determine the factors involved in polyethylene cracking. A qualitative laboratory test was developed to evaluate this property and the effect of a variety of organic and nonorganic materials was studied. It was found that the higher the molecular weight of a polyethylene the more resistant it becomes to cracking, that the degree of crystallinity affects its readiness to crack, and that the addition of polyisobutylene or Butyl rubber improves crack resistance.

This paper shows that useful end products, which are resistant to cracking, can be made from polyethylene.

*Atomic Relationships in the Cubic Twinned State.** W. C. ELLIS¹ and R. G. TREUTING¹. References. *Jl. Metals*, v. 191, pp. 53-55, Jan., 1951.

ABSTRACT—The twinned state is characterized by a lattice of coincidence sites. Imperfections are required at stable lateral twin interfaces. Twinned regions can occur with relative ease in the diamond cubic structure.

*Transitions in Chromium.** M. E. FINE¹, E. S. GREINER¹, and W. C. ELLIS¹. References. *Jl. Metals*, v. 191, pp. 56-58, Jan., 1951.

ABSTRACT—Discontinuous changes of Young's modulus, internal friction, coefficient of expansion, electrical resistivity, and thermoelectric power are evidence for a transition in chromium near 37° C. Although the X-ray

* A reprint of this article may be obtained on request.

¹ B. T. L.

diffraction pattern gives no clue, a difference between the thermal expansivity and the temperature dependence of the lattice parameter suggests a crystallographic change. Young's modulus data disclosed another transition near -152° C.

How to Measure Apparatus Noise. C. H. G. GRAY¹. *Standardization*, v. 22, pp. 55-56, Feb., 1951.

Fluorocarbon Hermetic Seal Design. A. B. HAINES¹. *Elec. Mfg.*, v. 47, pp. 113-115, Jan., 1951.

ABSTRACT—Terminal seals using molded trifluorochloroethylene resin solves sealing problem in design of miniaturized 400-cycle high-operating-temperature power transformers.

*Dynamic Shear Properties of Rubberlike Polymers.** I. L. HOPKINS¹. References. *A.S.M.E., Trans.*, v. 73, pp. 195-203; disc. pp. 203-204, Feb., 1951.

ABSTRACT—A simple apparatus for determining the dynamic properties of elastomers in shear at audio frequencies is appraised. Typical values of shear modulus and viscosity for several elastomers are given, both at room conditions and at 150 F. The frequencies of test range from 100 to 5250 cycles per second, the shear moduli from 0.5×10^6 to 480×10^6 dynes per sq cm and the viscosities from 20 to 75,000 poises.

Production-Line Frequency Measurements. G. J. KENT². *Electronics*, v. 24, pp. 97-99, Feb., 1951.

ABSTRACT—Simplified equipment allows relatively inexperienced personnel to make extremely accurate measurements of frequencies up to 10 mc. Entire system is standardized against WWV by simple adjustments while frequency measurement is being made.

*Progress in Development of Test Oscillators for Crystal Units.** L. F. KOERNER¹. *I.R.E., Proc.*, v. 39, pp. 16-26, Jan., 1951.

ABSTRACT—Early crystal unit test oscillators as conceived some 20 years ago were principally duplicates of the actual equipment in which the crystal units were to be utilized, a practice which resulted in a large variety of test circuits and procedures for testing. It is now recognized that a knowledge of the equivalent electrical elements making up the crystal unit is essential to the circuit engineer, and that the older conception of frequency and activity, the latter being an attempt to express the quality of a crystal unit in terms of a particular oscillator circuit, do not define adequately its characteristics. The equivalent electrical circuit of the crystal unit contains essentially a resistance, an inductance, and 2 capacitances, which together

* A reprint of this article may be obtained on request.

¹ B. T. L.

² W. E. Co.

with frequency define the performance of the unit. Crystal units are available in the frequency range from about 1,000 cycles to over 100 Mc. Their resistance range may vary from less than 10 ohms to over 150,000 ohms, the inductance from a few millihenries to nearly 100,000 henries and the capacitances from about 0.001 uuf to 50 uuf. Modern test oscillators, with frequency and capacitance measuring apparatus as auxiliary equipment, will measure these quantities with accuracies sufficient to meet present needs. The transmission measuring circuit also is described and is proposed as the standard reference circuit for comparison with the test oscillators.

*Local Wire Television Networks.** C. N. NEBEL¹. *Elec. Engg.*, v. 70, pp. 130-135, Feb., 1951.

ABSTRACT—A new local video distribution system has been developed which provides equalization and amplification of signals transmitted over links between television studios, transmitters, coaxial cables, and microwave networks. The equipment consists of a transmitting terminal, an intermediate repeater with cable equalizers, and a receiving terminal.

*Effect of Heat Treatment on the Electrical Properties of Germanium.** H. C. THEUERER¹ and J. H. SCAFF¹. *Jl. Metals*, v. 191, pp. 59-63, Jan., 1951.

ABSTRACT—Germanium may be reversibly converted from n to p type by heat treatment. Data for the conversion and the associated changes in resistivity are given and the results are interpreted in terms of changes in the donor-acceptor balance.

*Aging of Black Neoprene Jackets.** G. N. VACCA¹, R. H. ERICKSON¹, and C. V. LUNDBERG¹. References. *Ind. & Engg. Chem.*, v. 43, pp. 443-446, Feb., 1951.

ABSTRACT—Considerable loss in elongation of black neoprene jackets removed from wires which had been in outdoor service for comparatively short periods of time raised the question of the life expectancy of such coverings. Information available did not permit estimation of service life and a program of testing was undertaken to provide this information.

Accelerated aging tests corroborated by later field tests indicated that early loss of considerable elongation is not indicative of early failure in service as loss of elongation levels off and changes much more slowly on continued exposure.

Accelerated aging in air at temperatures up to 100° C. gave results most comparable with outdoor aging as regards loss of elongation. As a result of this work, it can be predicted with a good degree of reliability that a black neoprene jacket will remain serviceable for periods of the order of 20 years.

* A reprint of this article may be obtained on request.

¹ B. T. L.

Choice of Gauge in London's Approach to the Theory of Superconductivity. J. BARDEEN¹. Letter to the editor. *Phys. Rev.*, v. 81, pp. 469-470, Feb. 1, 1951.

Ferromagnetism. R. M. BOZORTH¹. N. Y., Van Nostrand, 1951. 968 p. (Bell Telephone Laboratories Series).

*Community Dial Office Equipment.** A. BURKETT¹. *Elec. Engg.*, v. 70, pp. 231-234, Mar., 1951.

ABSTRACT—Equipment for community dial offices which serve small or sparsely settled communities is described in this article. The discussion covers service features, equipment features, and maintenance facilities.

*Operational Study of a Highway Mobile Telephone System.** L. A. DORFF¹. *Elec. Engg.*, v. 70, pp. 236-241, Mar., 1951.

ABSTRACT—The problem of interference of nearby stations was one of the greatest problems which had to be overcome to permit the satisfactory use of mobile telephone service. This article tells of a study made of the interference encountered on one highway mobile telephone system and the measures made to counteract it.

A Precision Decade Oscillator for 20 Cycles to 200 Kilocycles. C. M. EDWARDS². *I.R.E., Proc.*, v. 39, pp. 277-278, Mar., 1951.

*The Control Chart as a Tool for Analyzing Experimental Data.** E. B. FERRELL¹. *I.R.E., Proc.*, v. 39, pp. 132-137, Feb., 1951.

ABSTRACT—The statistical methods that have been developed for use in quality control are a powerful tool in the interpretation of laboratory experiments where only a small amount of data is available. An understanding of these methods also permits more logical planning of experiments and improves what we might call "the efficiency of experimentation." One of the simplest and most broadly useful of these tools is the control chart. It is easy to understand and use and in many cases can take the place of more laborious and complicated methods of analysis.

Crystalline Magnetic Anisotropy in Zinc Manganese Ferrite. J. K. GALT¹, W. A. YAGER¹, J. P. REMEIK¹, and F. R. MERRITT¹. Letter to the editor. References. *Phys. Rev.*, v. 81, p. 470, Feb. 1, 1951.

*A Submarine Telephone Cable With Submerged Repeaters.** J. J. GILBERT¹. *Elec. Engg.*, v. 70, pp. 248-253, Mar., 1951.

ABSTRACT—Repeaters designed for long life are incorporated in the cable structure and are laid as part of the cable of the recently installed Key West-Havana submarine telephone cable system. To eliminate the need for servicing the repeaters, the components were designed so that parts would not have to be replaced for 20 years or more.

* A reprint of this article may be obtained on request.

¹ B. T. L.

² W. E. Co.

Measurement of Hole Diffusion in N-Type Germanium. F. S. GOUCHER¹. Letter to the editor. *Phys. Rev.*, v. 81, p. 475, Feb. 1, 1951.

Theory and Experiment for a Germanium P-N Junction. F. S. GOUCHER¹, G. L. PEARSON¹, M. SPARKS¹, G. K. TEAL¹, and W. SHOCKLEY¹. Letter to the editor. References. *Phys. Rev.*, v. 81, pp. 637-638, Feb. 15, 1951.

*Gain of Electromagnetic Horns.** W. C. JAKES, JR.¹ *I.R.E., Proc.*, v. 39, 160-162, Feb., 1951.

ABSTRACT—An experimental investigation of the gain of pyramidal electromagnetic horns is described. For the horns tested it was found that (1) the "edge effects" are less than 0.2 db so that the gain of the horns may be computed to that accuracy from their physical dimensions and Schelkunoff's curves; and (2) for the transmission of power between two horns the ordinary transmission formula is valid, provided that the separation distance between the horns is measured between the proper reference points on the horns, rather than between their apertures.

*A Pulse Method of Determining the Energy Distribution of Secondary Electrons from Insulators.** K. G. MCKAY¹. References. *Jl. Applied Phys.*, v. 22, pp. 89-94, Jan., 1951.

ABSTRACT—A novel method is described of determining the energy distribution of emitted secondaries from an insulator. This is based on an analysis of the transient resulting from pulse bombardment. The analysis is simplest when leakage through the target is negligible, but the effect of leakage is also treated. Space charge limitation of the emitted current is assumed to be negligible.

*Some General Properties of Magnetic Amplifiers.** J. M. MANLEY¹. References. *I.R.E., Proc.*, v. 39, pp. 242-251, Mar., 1951.

ABSTRACT—The magnetic amplifier is discussed in general terms as a carrier system in which there is a modulation gain and a small demodulation loss. Relations are given which show how a magnetic modulator may exhibit a gain.

Some results of calculation and measurement on the type of circuit in which the modulator output consists of the even harmonics of the carrier source for dc signal input are given. It is shown that the ratio of dc gain to response rise time is a constant depending only on the carrier frequency, the losses in the nonlinear core, and its nonlinearity. The conditions for self-oscillation at the carrier even harmonics are also given.

Influence of Rotatory Inertia and Shear on Flexural Motions of Isotropic, Elastic Plates. R. D. MINDLIN¹. References. *Jl. Applied Mech.*, v. 18, pp. 31-38, Mar., 1951.

* A reprint of this article may be obtained on request.

¹ B. T. L.

ABSTRACT—A two-dimensional theory of flexural motions of isotropic, elastic plates is deduced from the three-dimensional equations of elasticity. The theory includes the effects of rotatory inertia and shear in the same manner as Timoshenko's one-dimensional theory of bars. Velocities of straight-crested waves are computed and found to agree with those obtained from the three-dimensional theory. A uniqueness theorem reveals that three edge conditions are required.

Growth of Germanium Single Crystals Containing P-N Junctions. G. K. TEAL¹, M. SPARKS¹, and E. BUEHLER¹. Letter to the editor. *Phys. Rev.*, v. 81, p. 637, Feb. 15, 1951.

*A Mechanical Determination of Biaxial Residual Stress in Sheet Materials.** R. G. TREUTING¹ and W. T. READ, JR.¹ References. *Jl. Applied Phys.*, v. 22, pp. 130-134, Feb., 1951.

ABSTRACT—A method is given for determining the residual stress in a sheet material by removing successive uniform layers of material from the surface of a test specimen and measuring the resulting curvature. From the condition of equilibrium of a free specimen, a stress vs curvature relation is derived which holds over the depth to which material has been removed. The method applies when the stress is constant in the plane of the specimen and varies through the thickness. An experimental technique is described which is believed to satisfy the essential requirement that the removal of surface layers should not affect the stress in the remaining material, and a practical example is given.

*Improved Methods for Measuring Ultrasonic Velocity.** G. W. WILLARD¹. References. *Acoustical Soc. Am.*, *Jl.*, v. 23, pp. 83-93, Jan., 1951.

ABSTRACT—Some improved sound wave interference methods for measuring the longitudinal and transverse ultrasonic velocity in opaque as well as transparent solids may be simply carried out by using the ultrasonic light-diffraction system (as arranged for making sound beams visible on a screen). The sonic unit of the system is arranged to produce two individual traveling-wave sound beams, by use of two generators or by splitting a single beam. Three simple arrangements are described in detail. In Case A one beam travels entirely in a reference liquid, while the other beam travels a parallel path in an immersed transparent test specimen. In Case B one beam travels entirely in a reference liquid, while the other beam travels an adjacent course through an immersed, transparent or opaque test prism, and on into the liquid at an angle to the first beam. In Case C the two beams are generated at the equal edge faces of a transparent or opaque isosceles test prism (only

* A reprint of this article may be obtained on request.

¹ B. T. L.

the base edge face contacting the liquid). The two beams traverse the prism to the base, where they are refracted into the test liquid as confluent beams.

In Cases A and B, simulated interference (by optical integration), and in Case C true interference, each give a light and dark band interference pattern on the screen, whose band spacing is used in calculating the velocity of sound in the test solid. The other required factors are the optical image magnification, the frequency of the sound, the angular disposition of the one or more acoustic surfaces of the test solid relative to the incident sound beams, and in Cases A and B the velocity of sound in the reference medium. Other variations of arrangement are suggested.

Advantages of the improved methods are simple preparation of test specimen, directness and simplicity of measurement and calculation, good accuracy, low sonic power requirements. A table of measured velocities (and attenuations) in two metals and in numerous plastics and polymers show the wide range of materials that may be measured by the new interference methods.

Ferromagnetic Resonance in Various Ferrites. W. E. YAGER¹, F. R. MERRITT¹, and C. GUILLAUD¹. Letter to the editor. *Phys. Rev.*, v. 81, pp. 477-478, Feb. 1, 1951.

*The Study of Size and Shape by Means of Stereoscopic Electron Micrography.** C. J. CALBICK¹. *Photogrammetric Engineering*, v. 16, pp. 695-711, Dec., 1950.

*Electrical Excitation of Nerves in the Skin at Audiofrequencies.** A. B. ANDERSON¹ and W. A. MUNSON¹. References. *Acoustical Soc. Am., Jl.*, v. 23, pp. 155-159, Mar., 1951.

ABSTRACT—This is a report of results obtained in preliminary tests of perception of signals applied directly to the skin in the form of electrical potentials. The lowest signal level that could be felt and the highest level that could be applied without extreme discomfort to the observers were determined for sine wave potentials ranging from 100 to 10,000 cps. The difference between the lowest and highest levels was about 25 db over this frequency range.

Difference limen measurements for intensity and frequency showed that intensity discrimination is not greatly different from what it is for hearing but the ear is vastly superior in the matter of frequency discrimination.

Field Variation of Superconducting Penetration Depth. J. BARDEEN¹. Letter to the editor. References. *Phys. Rev.*, v. 81, pp. 1070-1071, Mar. 15, 1951.

Determination of the Effects of Dissipation in the Cochlear Partition by

* A reprint of this article may be obtained on request.

¹ B. T. L.

*Means of a Network Representing the Basilar Membrane.** B. P. BOGERT¹. *Acoustical Soc. Am., Jl.*, v. 23, pp. 151-154, Mar., 1951.

ABSTRACT—Results are given of measurements made on a 175-section network representing the basilar membrane, which was modified to include the effects of dissipation in the cochlear partition. The results show that the dynamical theory of the cochlea, when dissipation is considered, is in good agreement with experimental evidence.

A Professional Magnetic-Recording System for Use With 35-, 17½- and 16-Mm Films. G. R. CRANE⁴, J. G. FRAYNE⁴, and E. W. TEMPLIN⁴. *S.M.P.E., Jl.*, v. 56, pp. 295-309, Mar., 1951.

ABSTRACT—This paper describes a portable magnetic-recording system for producing high-quality sound tract in synchronism with pictures. The system has been designed to enable magnetic recording to conform with standard motion picture studio operating practices. A number of features such as high-speed rewind, interlocked-switching facilities, one basic type of amplifier and the use of miniature tubes throughout have been incorporated in the system.

*Additional Continuous Sampling Inspection Plans.** H. F. DODGE¹ and M. N. TORREY¹. *Ind. Quality Control*, v. 7, pp. 7-12, Mar., 1951.

*The Mobility and Life of Injected Holes and Electrons in Germanium.** J. R. HAYNES¹ and W. SHOCKLEY¹. Bibliography. *Phys. Rev.*, v. 81, pp. 835-843, Mar. 1, 1951.

ABSTRACT—The mobilities of holes injected into n-type germanium and of electrons injected into p-type germanium have been determined by measuring transit times between emitter and collector in single crystal rods. Strong electric fields in addition to those due to injected current were employed so that spreading effects due to diffusions were reduced. The mobilities at 300°K are 1700 cm²/volt-sec for holes and 3600 cm²/volt-sec for electrons with an error of probably less than five percent. The value for electrons is about 20 percent higher than the best estimates obtained from the conventional interpretation of the Hall effect and the difference may be due to curved energy band surfaces in the Brillouin zone. Studies of rates of decay indicate that recombination of holes and electrons takes place largely on the surface of small samples with constants varying from 10² to >10⁴ cm/sec for special treatments.

*On the Theory of Spin Waves in Ferromagnetic Media.** C. HERRING¹ and C. KITTEL¹. Bibliography. *Phys. Rev.*, v. 81, pp. 869-880, Mar. 1, 1951.

ABSTRACT—The theory of spin waves, leading to the Bloch T^{3/2} law for the

* A reprint of this article may be obtained on request.

¹ B. T. L.

⁴ Westrex Corp.

temperature variation of saturation magnetization, is discussed for ferromagnetic insulators and metals, with emphasis on its relation to the theory of the energy of the Bloch interdomain wall. The analysis indicates that spin-wave theory is of more general validity than the Heitler-London-Heisenberg model from which it was originally derived. Many properties of spin waves of long wavelength can be derived without specialized assumptions, by a field-theoretical treatment of the ferromagnetic material as a continuous medium in which the densities of the three components of spin are regarded as amplitudes of a quantized vector field. As applications, the effects of anisotropy energy and magnetic forces are calculated; and it is shown that the Holstein-Primakoff result for the field dependence of the saturation magnetization can be derived in an elementary manner. An examination of the conditions for validity of the field theory indicates that it should be valid for insulators, and probably also for metals, independently of any simplifying assumptions. The connection with the itinerant electron model of a metal is discussed; it appears that this model is incomplete in that it omits certain spin wave states which can be proved to exist, and that when these are included, it will yield both a magnetization reversal proportional to T^3 and a specific heat proportional to T . Incidental results include some insight into the relation between the exchange and Ising models for a two-dimensional lattice, an upper limit to the effective exchange integral, and a treatment of spin waves in rhombic lattices.

*Educational Patterns in U. S. and England.** M. J. KELLY¹. *Jl. Engg. Education*, v. 41, pp. 358-361, Mar., 1951.

*A Barium Titanate Transducer Capable of Large Motion at an Ultrasonic Frequency.** W. P. MASON¹ and R. F. WICK¹. *Acoustical Soc. Am., Jl.*, v. 23, pp. 209-214, Mar., 1951.

ABSTRACT—By using a barium titanate cylinder poled radially a lengthwise motion can be excited in the cylinder whose resonant frequency is controlled by the length of the cylinder. By using a 4 percent lead titanate-barium titanate combination, stresses up to 1000 pounds per square inch of cross-sectional dimension and motions up to 50 parts in 10^6 times the length of the cylinder are available for static or slowly varying voltages of 15,000 volts per centimeter along the radial dimension. When such a cylinder is driven at its resonant frequency, the maximum strain appears to be limited to 10^{-4} by heating considerations if no cooling is used. For a cylinder 12 centimeters long, which resonates at 18 kilocycles, this corresponds to a displacement on each end of 3.9×10^{-4} cm, a particle velocity of 44 cm/sec and an acceleration of 5×10^6 cm/sec/sec. All of these quantities can be en-

* A reprint of this article may be obtained on request.

¹ B. T. L.

hanced by a factor of 10 by soldering a solid brass "horn," tapered exponential, to the end of the barium titanate cylinder. If the large end of the horn, which is soldered to the cylinder, is 10 times the diameter of the small end, the horn acts as a transformer to increase the particle motion by a factor of 10. Hence, a 1.5-mil motion is possible with this combination at 18 kilocycles. This structure has been made the basis of several instruments used for testing wear, for measuring magnetic flux, for testing adhesion of films, and for boring odd-shaped holes. A feedback amplifier system with a diode limiting element is used to keep the amplitude constant.

*Transmission-Line Equivalent of Electronic Traveling-Wave Systems.** W. E. MATHEWS¹. References. *Jl. Applied Phys.*, v. 22, pp. 310-316, Mar., 1951.

ABSTRACT—It is well known that the small-signal behavior of long electron beams may be analyzed in terms of propagating space-charge waves suggesting an equivalence between such beams and longitudinally moving transmission lines. This in turn suggests the analysis of such electronic devices as the traveling-wave amplifier, double-stream or electron-wave amplifier, and multicavity magnetron, in terms of coupled distributed-parameter transmission lines moving relative to each other. It is shown that this approach is equivalent to a rigorous field-theory analysis in certain cases of particular interest, and the procedure for calculating the significant distributed parameters is indicated. Final results for the idealized helix and thin cylindrical electron beam are presented.

Electronic Music for Four. L. A. MEACHAM¹. *Electronics*, v. 24, pp. 76-79, Feb., 1951.

Thickness-Shear and Flexural Vibrations of Crystal Plates. R. D. MINDLIN¹. References. *Jl. Applied Phys.*, v. 22, pp. 316-323, Mar., 1951.

ABSTRACT—The theory of flexural motions of elastic plates, including the effects of rotatory inertia and shear, is extended to crystal plates. The equations are solved approximately for the case of rectangular plates excited by thickness-shear deformation parallel to one edge. Results of computations of resonant frequencies of rectangular, AT-cut, quartz plates are shown and compared with experimental data. Simple algebraic formulas are obtained relating frequency, dimensions, and crystal properties for resonances of special interest in design.

Television Transmission in Local Telephone Exchange Areas. L. W. MORRISON¹. *S.M.P.E.*, *Jl.*, v. 56, pp. 280-294, Mar., 1951.

ABSTRACT—The functions of a video transmission system in a local exchange area in providing mobility for the pickup camera and interconnection

* A reprint of this article may be obtained on request.

¹ B. T. L.

with the intercity networks are discussed; and an analysis of some of the television transmission problems is presented. A description is given of the physical and electrical characteristics of the various types of cable facilities, the video amplifiers, and equalizers now employed; and an example of the television transmission performance obtained is included.

Significance of Composition of Contact Point in Rectifying Junctions on Germanium. W. G. PFANN¹. Letter to the editor. References. *Phys. Rev.*, v. 81, p. 882, Mar. 1, 1951.

*The Characteristics and Some Applications of Varistors.** F. R. STANSEL¹. Bibliography. *I.R.E., Proc.*, v. 39, pp. 342-358, Apr., 1951.

ABSTRACT—Varistors, circuit elements whose resistance is a function of the voltage applied, represent one important commercial application of semiconductors. They may be divided into two classifications: nonsymmetrical and symmetrical varistors. The first classification includes both metallic rectifiers such as copper oxide, selenium, and copper sulfide, and point contact rectifiers such as silicon and germanium. The only commercial varistor of the symmetrical class is the silicon carbide varistor, although a symmetrical characteristic may be obtained by connecting two nonsymmetrical varistors in parallel with proper polarity.

Each varistor has its volt-ampere characteristic and at each point on this characteristic two different values of resistance may be defined, namely the dc resistance, defined as the ratio of voltage to current, and the dynamic or ac resistance, defined as the ratio of dE to dI . The former is important in problems dealing with steady-state dc or large-signal applications, while the latter is important when dealing with small applied signals.

Because of the state of the art, varistors as manufactured commercially are less uniform than many other circuit elements and required uniformity is often obtained by special selection. Economical use of these elements therefore requires the circuit engineer to recognize clearly which of the several properties are important in his application and to specify special selection for only those properties and to the extent necessary for his application.

Other properties of varistors which may be of importance are capacitance, maximum inverse voltage, effect of temperature and frequency on any of the other characteristics, long and short time stability, and noise.

Of the many applications of varistors three are discussed which illustrate how different properties may be determining factors in different applications. In power rectifiers the limiting factors are those which may physically damage the unit, energy dissipated within the varistor, and inverse voltage

* A reprint of this article may be obtained on request.

¹ B. T. L.

across the varistor. As a result such items as ventilation, duty cycle, and the like, are important. In bridge- and ring-(lattice) type modulators the problem of protecting the varistor against physical breakdown is seldom present, but the limiting factor is the extraneous modulation products introduced into the circuit. It is therefore necessary to make detailed analyses of the spectrum of the sum and difference products involved. In the compandor (compressor plus expander), operating economies are obtained by a device which is dependent on the uniformity of the dynamic characteristic of the varistor in its forward direction. A selected bibliography is included.

Japan's Recovery and Telephone Service. H. F. VAN ZANDT³. *Telephony*, v. 140, pp. 15-17, 46, Mar. 24, 1951.

Growing Quartz Crystals for Military Needs. A. C. WALKER¹. *Electronics*, v. 24, pp. 96-99, Apr., 1951.

ABSTRACT—Perfected technique gives large, perfect crystals in quantities that mean eventual independence of Brazilian sources. Quartz scrap, alkaline solution and seed plates are sealed into steel bomb by welding, then heated to 400 C to develop 15,000 psi for optimum growth.

*Relation between Lattice Vibration and London Theories of Superconductivity.** J. BARDEEN¹. References. *Phys. Rev.*, v. 81, pp. 829-834, Mar. 1, 1951.

ABSTRACT—A gas of noninteracting electrons of small effective mass, m_{eff} , has a large diamagnetic susceptibility. It is shown that the London phenomenological equations of superconductivity follow as a limiting case when m_{eff} is so small that the Landau-Peierls theory yields a susceptibility $< -\frac{1}{4}\pi$. Justification is given for the use of an effective mass, $m_s \sim 10^{-4} m$, for superconducting electrons in the lattice-vibration theory of superconductivity. This value is sufficiently small to show that the theory gives the London equations and, as a consequence, the typical superconducting properties. The concentration of superconducting electrons, n_s , is smaller than the total electron concentration, n , by about the same ratio as the effective masses, so that $m_s/n_s \sim m/n$, and thus the penetration depth is of the same order as that given by the usual London expression.

* A reprint of this article may be obtained on request.

¹ B. T. L.

³ Southwestern Bell Telephone Company